Aquatic Microfauna within Australian Inland Waters

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The issue I am bringing to your attention is one of the most important and basic ecological elements of Australian freshwater systems, i.e. aquatic microfauna (ZOOPLANKTON). It is this microfauna that is more prevalent in our lakes, wetlands, dam's, reservoirs, ponds, impoundments and temporary waters; not aquatic macro-invertebrates, which prefer shallow flowing waters.

The issue I am raising is not based on emotions or false perception, but over 20 years of scientific research and actual hands on fresh water natural resource management. I have worked in the field of freshwater science (Limnology) in South Eastern Australia for the past 20 years. During this time I have been employed at the Australian Water Quality Centre (AWQC) and at the Murray Darling Freshwater Research Centre (CSIRO). The two major freshwater research centres in the Commonwealth of Australia. In 2005, I established Australian Waterlife, one of less than a handful of laboratories to identify freshwater microfauna.

Currently, nearly everything we know about the ecology of our inland waters and waterways is based on aquatic macro-invertebrates, and the AUSRIVAS methodology and SIGNAL protocol used in monitoring of the Australia's river systems. Macro-invertebrates are animals without a back bone and larger than 2mm in body length, prevalent in river systems and inland waters. On the other hand, aquatic micro-invertebrates, the building block of the freshwater ecosystem and food webs have not been the focus of the same degree of research or management. These are those tiny aquatic animals smaller than 2mm and typically comprise the Microcrustacea (Cladocera, Copepoda, Ostracoda) and the Rotifera.

Better understanding of aquatic micro-invertebrates within our fresh waters is a priority (Sheil 1998). Their species composition and abundance are the best indicator for the health of our lakes, wetlands, reservoirs, and impoundments. They are more common, prevalent and numerous than macro-invertebrates, as well as an important food source for our macro-invertebrates and fish (Gilbert & Burns 1999; Hampton & Gilbert 2001; Hampton *et al* 2000). Many also prey on insect larvae (Marten 1990) and fish larvae (Davis 1959). Their species composition and abundance will therefore impact upon fish stocks, both our conservation of important natives and commercially important introduced species. They also have a very important role in minimising the establishment risk of introduced pest species, such as carp (Piasecki 2000; Fabian 1960).

A fundamental flaw in our current understanding and, as a result, management of fresh water bodies in South Eastern Australia is our reliance on AUSRIVAS. It is the model used by all State Governments to gain an understanding of the ecology of their inland waters and is used to determine the ecology and health of flowing systems (rivers, streams and creeks),

However, AUSRIVAS is macro-invertebrate orientated, with nearly all of the fauna encountered in this model being river-based. As a result, all of the aquatic ecological models on which we base our management, have been written for Rivers and flowing waters. In contrast, little has been put forward for slow moving rivers and standing bodies of water such as lakes, dams, ponds, reservoirs, impoundments, etc, both temporary and permanent. This represents a serious gap in our knowledge base for the management of standing waters and has the potential for far reaching consequences in our ability to maintain the health of our lakes (ponds, dams etc) and the industries that rely upon them. Compared to flowing waters, the planktonic and benthic micro-invertebrate fauna of lakes etc may be relatively diverse, habitat specific and may number in the 1000s per litre.

The AUSRIVAS model actually down plays the role of the micro-invertebrates because of its focus on flowing waters. These flowing waters provide a more extreme environment for micro-invertebrates. Thus there is often a reduction in their biomass and diversity within such habitats. This is particularly important for the management of standing water bodies. For example *Daphnia lumhotzi*, a cladoceran found in Australian waters has been accidently introduced into the Missouri River, USA. This species outcompetes the native aquatic microfauna: consuming algae with a more rapid turn-over time and growth, resulting in riverine ecosystem damage to the Missouri. The same species has invaded Brazilian (Zanata et. al. 2003) and Argentinian rivers (Kotov & Taylor 2014) with similar consequences.

Currently little is done to monitor Australian bodies of water. This is despite their high value in terms of water quality and for the tourism, and recreational fishing industries. What has been completed has almost exclusively been undertaken by students and academics at various Universities.

Why is an understanding of micro-invertebrates in our lakes, ponds, billabongs etc so important? To put it simply they are believed to be the *most important link in the aquatic food web*, as they link the components of the aquatic food web together. They consume algae, protists and bacteria; insect larvae such as mosquitoes (Marten 1990; Marten et al 2000), they predate on each other, and may even consume early larval fish -eg Carp (Davis 1959). Overseas research has indicated that microcrustaceans eat 1-2 day old fish larvae (Hartig *et al* 1992) including Carp with a mortality rate of 90% (Piasecki 2000; Fabian 1960). In turn they are a food source for macro-invertebrates (Gilbert & Burns 1999; Hampton & Gilbert 2001; Hampton *et al* 2000), larval and juvenile fish (King 2004), and small fish species such as bony bream (*Nematolosa erebi*), carp gudgeon (*Hypseleotris* spp.), flathead gudgeon (*Philypnodon grandiceps*), Murray hardyhead (*Craterocephalus fluviatilis*), rainbowfish (*Melanotaenia fluviatilis*), Australian smelt (*Retropinna semoni*) (Vilizzi and Meredith 2009), and our conservation important galaxids.

After bacteria and phytoplankton, micro-invertebrates (rotifers and microcrustaceans) are commonly the most abundant organisms in inland waters. In addition micro-invertebrates provide a link with decomposition pathways within aquatic systems. They are more sensitive than higher invertebrates or fish to changes in water quality, possess rapid generation times and often reach high population densities. These rapid response times make them ideal environmental indicators of health of aquatic systems – a value not presently used in Australia.

The micro-invertebrates of inland waters are a vital component of aquatic ecosystems. Any of our activities which act directly or indirectly to reduce their number or diversity may have far reaching ramifications that may include removing their grazing influence on algae or bacteria (thus possibly causing blooms), and removing them as food items from higher organisms. Because of their often large numbers, aquatic micro-invertebrates consume vast amounts of organic material, and by reducing the amount of phytoplankton, are important in maintaining water clarity and health of standing bodies of inland waters (eg water treatment plants).

A vital and important link in food chains/webs of virtually every inland body of water, aquatic micro-invertebrates convert phytoplankton, benthic plants and decaying organic matter into animal tissue. Bottom-dwelling species are prime converters of decaying organic matter into a form usable by fish and larger invertebrates. In large water bodies planktonic microcrustaceans are not only a major food source for many kinds of fish (King 2004), but also aquatic insect larvae and other invertebrates also feed on micro-invertebrates (Gilbert & Burns 1999; Hampton & Gilbert 2001; Hampton et al 2000). Most fresh water ecosystems would collapse quickly if they were removed.

Some species of the microcrustacean cyclopoid genera such those belonging to the genera *Metacyclops, Tropocyclops,* , *Eucyclops, Macrocyclops* and *Mesocyclops* are biological control agents for disease-bearing mosquitoes (Marten 1990; Maerten et al 2000; Rey et al 2004).

Predatory Ostrocads common in many temporary and permanent wetlands have been reported consuming the eggs of frogs with a mortality rate of up to 90% (Grey et al 2010). Others have been observed consuming aquatic snails.

In Europe, an increasing number of cyclopoid copepod species are actually revealing their noteworthy importance as "pollution markers" in the environmental control of aquatic habitats, e.g. lakes, springs, rivers and superficial ground waters.

Aquatic microfauna are an important part of the diet of aquatic birds. For example, the diet of adult swans consists mainly of aquatic vegetation. In contrast, young swans (cygnets) need a protein rich diet, consuming small crustaceans and insects. Similarly ducks and geese also consume a wide variety of aquatic plant material, plus associated microcrustaceans.

Therefore, the presence or absence of microcrustacean species in a water body may provide us with useful ecological information. In addition, the inclusion of aquatic microfaunal community analysis can help provide a more thorough understanding of water quality.

This faunal group is often ignored by our aquatic researchers/consultants, and therefore by environmental managers of inland water waters, regulatory authorities and decision makers.

Likewise, even conservation groups seem to have little focus on this situation because of the lack of awareness and knowledge.

At the moment because of this, the various authorities do not conduct any work on aquatic microfauna due to this lack of knowledge within Australia. Though there has been some work conducted on aquatic microfauna of the 2,500 lake systems in Central Tasmania (Walsh & Tyler 1998, 2000), the Western Australian coastal lakes (Chessman et al 2002) and in south-eastern Australia (Spencer at al 1998). However this lack of investigation, research, knowledge and expertise is in stark contrast to the Northern Hemisphere – Africa (Labarbera & Kilham 1974; Fafioye & Omoyinmi 2006), Canada (Patalas 1971; Shaw & Kelso1992), United Kingdom (Nicolet et al 2004), Belgium (de Bie et al 2008), Ireland (Duigan 1992; de Eyto et al 2002), Finland (Arvola 1986; Ilmaverta et al 1984) , Spain (Boix et al. 2005), United States (Gannon & Stemberger 1978; Pinto-Coelho et al. 2005), Malaysia (Lai & Fenando 1978), plus New Zealand (Duggan et al 2001) and South America (Landa et al 2007; Pinto-Coelho et al 2005). These are only a few of the published, literature reviewed papers on the subject.

Given the importance of our micro-invertebrates and our water systems, both man-made and natural to Australia from conservation, social and economic view points, there is a need to address the current knowledge gaps and management circumstances. This is before the benefits that come from our unique wetland systems, lakes, temporary rivers, and natural ecosystems are lost because of a lack of knowledge and the potential failing to manage these resources sustainably.

REFERENCES:

L. Arvola (1986). "Spring phytoplankton of 54 small lakes in southern Finland." Hydrobiologia **137**: 125-134.

D. Boix, S. Gascon, J. Sala, M. Martinoy, J. Gifre & X.D. Quintana (2005). A new index of water quality assessment in Mediterranean wetlands based on crustacean and insect assemblages : the case of Catalunya (NE Iberian Peninsula). Aquatic Conservation: Marine and Freshwater Ecosystems. **15**: pp 635-651.

B. Chessman, K. M. Trayler, and J.A. Davis (2002). "Family- and Species-level biotic indices for macroinvertebrates of wetlands on the Swan Coastal Plain, Western Australia." Marine and Freshwater Research **53**: 919-930.

C. Davis (1959) The damage done to fish fry by cyclopoid copepods. Ohio Journal of Sciences. **59**(2): 101-102.

E. de Eyto, K. Irvine, et al. (2002). "The use of members of the family Chydoridae (Anomopoda, Branchiopoda) as an indicator of lake ecological quality in Ireland." Proceedings of the Royal Irish Academy **102B**(2): 81-91.

I.C. Duggan, J.D. Green and R.J. Shiel (2001) Distribution of rotifers in North Island , New Zealand, and their potential use as bioindicators of lake trophic status. Hydrobiologia **446/447**: 155-164.

M. Fabian (1960) Mortality of freshwater and tropical fish fry by cyclopoid copepods. Ohio Journal of Sciences. **60**(5): 268-270.

Fafioye, O. O. & G. A. K. Omoyinmi (2006). "The Rotifers of Omi River, Ago-iwoye, Nigeria." African Journal of Agricultural Research **1**(5): 186-188.

J. E. Gannon & R. S. Stemberger (1978). Zooplankton (especially crustaceans and rotifers) as indicators of water quality. Transcriptions of the American Microscopy Society **97**(1): 16-35.

J.J. Gilbert & C.W. Burns (1999) Some observations on the diet of backswimmer, *Anisops wakefieldi* (Hemiptera: Notonectidae). Hydrobiologia **412**: pp 111-118.

E.P. Grey, S. Nunziata, J.W. Snodgrass, D.R. Ownby, & J.Havel. (2010). Predation on Green Frog Eggs (*Rana clamitans*) by Ostracoda. Copeia 3: 452-456.

S.E. Hampton & J.J. Gilbert (2001) Observations on insect predation on rotifers. Hydrobiologia **446/447** pp 115-121.

S.E. Hampton, J.J. Gilbert & C.W. Burns (2000) Direct and indirect affects of juvenile Buenoa macrotibialis (Hemiptera: Notonectidae) on the zooplankton of a shallow pond. Limnology and Oceanography. Vol **45**(4) : pp 1006-1012.

H.H. Hartig, Jude, D.J. & Evens, M.S. (1982). Cyclopoid predation on Lake Michigan fish larvae. Canadian Journal of Fisheries & Aquatic Sciences, **39,** 1563-1568.

J.E. Havel & Herbert P.D.N. (1993). Daphnia lumholtzi in North America: another exotic zooplankter. Limnol. Oceanogr. **38:**1823-1827.

K. P Ilmavirta, Huttunen, & Merilainen, J. (1984). "Phytoplankton in 151 eastern Finnish lakes: Species composition and its relations to the water chemistry." Verh. Internat. Verein. Limnol. **22**: 822-828.

King, A. J. (2004). "Density and distribuion of potential prey for larval fish in the main channel of a floodplain river: pelagic versus epibenthic meiofuna." River Research and Applications **20**: 883-897.

A.A. Kotov & Taylor D.J. (2014). *Daphnia lumholtzi* Sars, 1885(Cladocera: Daphniidae) invades Argentinia.

Labarbera, M. C. & P. Kilham (1974). "The chemical ecology of copepod distribution in the lakes of east and central Africa." Limnology and Oceanography **19**(3): 459-465.

A.A. Labay & Brandt, T.M. (1994). Predation by *Cyclops vernalis* on Florida Largemouth Bass and Fountain Darter Larvae. The Progressive Fish-Culturist, **56** (1)**,** 37-39.

G. G. Marten, (1990). "Elimination of *Aedes albopictus* from tire piles by introducing *Macrocyclops albidus* (Copepoda, Cyclopidae)." Journal of the American Mosquito Control Association **6**(4): 689-693.

G. G. Marten, M. Nguyen, et al. (2000). "Natural control of *Culex quiquefasciatus* larvae in residencetial ditches by the copepod *Macrocyclops albidus*." Journal of Vector Ecology **25**(1): 7-15.

P. Nicolet, J. Biggs, G. Fox, M.J. Hodson, C. Reynilds, M. Whifield & P. Williams (2004) The wetland plant community and macroinvertebrate assemblages of temporary ponds in England and Wales. Biological Conservation **120**: 261-278.

W. Piasecki (2000) Attacks of cyclopoid *Acanthocyclops robustus* (SARS) on newly hatched cyprinids. EJPAU 3(1):1-11.

K. Patalas (1971). "Crustacean plankton communities in 45 lakes in the experimental lakes area, Northwestern Ontario." J. Fish. Bd. Can. **28**: 231-244.

R. M. Pinto-Coelho, B. Pinel-alloul, et al. (2005). "Crustacean zooplankton in lakes and reservoirs of temperate and tropical regions: variation with trophic status." Canadian Journal of Fisheries and Aquatic Sciences **62**: 348-361.

J.R. Rey, S.O'Connell, S. Suarez, Z. Menendez, L.P. Lounibos & G. Byer. (2004). Laboratory and field studies of *Macrocyclops albidus* (Crustacea, Copepoda) for biological control of mosquitoes in artificial containers in a sub-tropical environment. Journal of Vector Biology **29**(1): 124-134.

M. A. Shaw & J. R. M. Kelso (1992). "Environmental factors influencing zooplankton species composition of lakes of north-central Ontario, Canada." Hydrobiologia **241**: 141-154.

R. Shiel (1998). Should we care about Microfauna? Water-Australian Water & Waste Water Association **25**(3) May/June 1998 pp11-12.

C. Spencer, Robertson A.A, Curtis A. (1998). Development and testing of a rapid appraisal wetland condition index in south-eastern Australia. Journal of Environmental Management **54**, 143-159.

R.G.J. Walsh & P.A. Tyler (1998). Reconnaissance Limnology of Tasmania. IV. The distribution and ecological preference of Tasmanian species of calanoid copepods (Crustacea: Centropagidae). Archive fur Hydrobiologie. **141**(4):403-420

R.G.J. Walsh & P.A. Tyler (2000). Reconnaissance Limnology of Tasmania. V. Anthropogenic factors in the distribution of calanoid copepods in Tasmanian lakes. Archive fur Hydrobiologie. **148**(4): 625-638.